UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF WATER MANAGEMENT PROGRAMME FOR THE TANJUNG KARANG RICE IRRIGATION PROJECT USING GEOGRAPHIC INFORMATION SYSTEM (GIS)

ABEDA KHATUN

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By

ABEDA KHATUN

Thesis Submitted in Partial Fulfillment of the Requirements for the degree of Master of Science in the Faculty of Engineering
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February 2000

Dedicated to

my

beloved son Ahnaf Tahmid,

daughter Farhat Tahsin

&

the memory of my beloved Parents

Abstract of this thesis presented to the Senate of Universiti Putra Malaysia in partial fulfillment of the requirements for the degree of Master of Science.

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February 2000

Chairman: **Associate Professor Dr. Ir. Mohd. Amin Mohd. Soom**

Faculty: **Engineering**

Water plays an important role in crop production. Good water management can improve the irrigation efficiency and the potential to greatly increase crop production. The water availability is dependent on rainfall and irrigation system characteristics. In contributing to the process of decision making the irrigation personnel needs to understand the rainfall pattern and irrigation water demand of the whole system. The Tanjung Karang Rice Irrigation Project in Northwest Selangor Malaysia was selected for this study and the tertiary canal TASB-4 of Sungui Burung compartment was considered as the main study area.

Geographic information system (GIS) is becoming an increasingly powerful tool used in water management system for paddy field irrigation. The Tanjung Karang Rice Irrigation Project and soil maps were digitized by the use of MapInfo Software. Different types of map features such as scheme, compartments, canals, rivers, roads and soils were digitized and stored into different layers. Relevant physical and management data were collected from various sources and input into a database. The application of the GIS software through the development and presentation of water distribution system using tables, maps and graphs were illustrated. Real and some estimated data, using established technique were input into MapInfo browser tables for each compartment.

Proper water budgeting is a prerequisite condition of any successful irrigation project. In an irrigation project, the amount of water to be applied is an important factor. Irrigation scheduling which anticipates the temporal water need of crops i.e. when to irrigate and how much water to apply is an important management activity affecting the performance of the irrigation project. A water budget for dry and normal year was prepared on the basis of the rainfall availability (1950-1997) in the project area. In off-

season the total design water requirement was 1314 mm but the total mean rainfall was 444 mm, and in 1 in 5 dry year was 382 mm. So 870 mm and 932 mm of additional water was required for normal and 1 in 5 dry year respectively. Similarly in the main season, the total design water requirement was 1589 mm but the total mean rainfall was 730 mm and 643 mm in 1 in 5 dry year. So 859 mm and 946 mm of additional water was required for normal and 1 in 5 dry year.

A cropping schedule calendar was prepared on weekly interval. And on the basis of the calendar, scheduling browser tables of the eight compartments were developed. The water duty of the project area calculated for the 1st pre-saturation period was 2.78 l/sec/ha, second pre-saturation period was 1.85 l/sec/ha and normal supply period was 1.17 l/sec/ha. On the basis of the water duty the irrigation scheduling was then calculated.

Other than downstream areas furthest from the main canal, the soils with high percolation rate also influence the quantity of irrigation water available. On the basis of the particle size analysis of the overall soil series, the Jawa, Sedu, and Brown Clay soil series were found to be potential water stress areas of the Tanjung Karang Rice Irrigation Scheme. The Sekinchan compartment was identified as the best productive compartment.

By using GIS to monitor the water management, spatial analysis was carried out easily and effectively for modification or maintenance resulting in better water management. Besides, design of water distribution or timely irrigation could also be done to increase the uniformity, efficiency and adequacy of water delivery systems.

Abastrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi sebahagian daripada keperluan untuk ijazah Master Sains.

PEMBANGUNAN PROGRAM PENGURUSAN AIR UNTUK PROJEK PENGAIRAN TANJUNG KARANG MENGGUNAKAN SISTEM MAKLUMAT GEOGRAFI

Oleh

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Air memainkan peranan yang penting dalam pengeluaran tanaman. Melalui pengurusan air yang baik, kecekapan pengairan dapat dipertingkatkan dan juga berpotensi untuk menambahkan pengeluaran pertanian. Air yang sedia ada adalah bergantung kepada air hujan dan ciri-ciri sistem pengairan. Dalam proses membuat keputusan, jurutera pengairan perlu memahami taburan hujan dan keperluan pengairan seluruh sistem. Memandangkan mereka dipertanggungjawabkan untuk membekalkan air, pemahaman tentang pengurusan pengairan semasa adalah penting. Projek Pengairan Padi di Tanjung Karang yang terletak di barat laut Selangor dipilih untuk kajian ini dan TASB-4 di kompatmen Sungai Burung pula dianggap sebagai kawasan kajian yang utama.

Sistem maklumat geografi ialah alat yang semakin berguna dalam sistem pengurusan air untuk pengairan padi. Sistem pengairan Tanjung Karang dan peta tanah telah didigitkan dengan perisian Mapinfo GIS. Peta yang berbeza kategori seperti skim, kompatmen, terusan, sungai, jalan dan tanah telah didigitkan dan disimpan dalam lapisan yang berbeza. Data pengurusan dan fizikal yang berkaitan dikumpulkan daripada pelbagai sumber input dan dimasukkan ke dalam pangkalan data. Pembangunan dan persembahan sistem taburan air yang menggunakan jadual, peta, and graf dapat dipaparkan melalui penggunaan perisian sistem maklumat geografi. Sebilangan data anggaran dan benar yang menggunakan teknik yang sudah wujud boleh dimasukkan ke dalam jadual mapinfo browser untuk setiap kompatmen.

Anggaran air yang betul adalah amat diingini oleh projek pengairan yang berjaya. Di dalam projek pengairan, jumlah air yang digunakan adalah faktor yang penting. Penjadualan pengairan untuk keperluan tanaman yang sementara seperti bila

untuk memberi pengairan dan berapa banyak air perlu digunakan adalah faktor yang penting yang akan mempengaruhi prestasi projek pengairan. Anggaran air untuk tahun yang normal dan tahun kemarau disediakan berdasarkan hujan (1950-1997) di kawasan projek. Pada luar musim, jumlah keperluan air rekabentuk yang direka adalah 1314 mm tetapi jumlah purata air hujan adalah sebanyak 444 mm dan semasa tahun kemarau 1 dalam 5 hujannya ialah 382 mm dengan pertambahan air masing-masing sebanyak 870 mm dan 932 mm. Begitu juga dengan keadaan semasa musim utama dimana keperluan air rekabentk adalah 1589 mm tetapi jumlah purata air hujan ialah 730 mm dan 643 mm semasa tahun kemaru 1:5. Jadi tambahan air masing-masing sebanyak 859mm dan 946 mm adalah diperlukan.

Penjadualan disediakan dalam tempoh mingguan. Jumlah keperluan air dan kehilangan semasa penyediaan tanah, penaburan biji benih, peringkat pertumbuhan dan musim penuaian telah dianggarkan untuk setiap kompatmen dan juga seluruh skim. Berdasarkan kalendar penjadualan, jadual browser dari lapan kompatmen telah dibuat. Tugas air untuk kawasan projek yang telah dikira untuk pra-tepu yang pertama adalah 2.78 l/s/ha. Pra-tepu yang kedua ialah 1.85 l/s/ha dan untuk pembekalan yang biasa ialah 1.17 l/s/h. Berdasarkan tugas air tersebut satu rangka jadual pengairan telah ditetapkan berdasarkan pengiraan.

Selain daripada kawasan hilir yang berjauhan daripada terusan utama, kadar penelusan dalam bagi tanah juga mempengaruhi kuantiti air pengairan yang ada. Berdasarkan analisis saiz zarah untuk kesemua siri tanah yang didapati, tanah siri Jawa, Sedu, dan Liat coklet adalah kawasan yang berpotensi untuk kekurangan air ber laku di skim pergairan padi Tanjung Karang. Kompatmen Sekinchan telah dikenalpasti sebagai kompatmen yang berhasil terbaik.

Dengan menggunakan sistem maklumat geografi untuk mengawal pengurusan air, analisis dapat dilaksanakan dengan lebih senang dan berkesan untuk pembetulan atau penyelenggaraan supaya mendapat pengurusan air yang baik. Selain itu, perekaan untuk agihan air atau tempoh pengairan dapat juga dilaksanakan untuk meningkatkan keseragaman, kecekapan dan kecukupan sistem penyaluran air.

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I certify that an Examination Committee met on 15 February, 2000 to conduct the final examination of Abeda Khatun, on her Master of Science thesis entitled "Development of Water Management Programme for the Tanjung Karang Rice Irrigation Project Using Geographic Information System (GIS)" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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Statement of Originality

Except where specific acknowledgment is given, the research work reported in this thesis is entirely that of the author.

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Date: 21.2.2000

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BRH	-	Bernam River Headworks
CHO	-	Constant Head Orifice
CRW	-	Crop Water Requirement
CRWS	-	Cumulative Relative Water Supply
CPU	-	Central Processing Unit
DID	-	Drainage and Irrigation Department
DR	-	Drainage
ET	-	Evapotranspiration
ERF	-	Effective Rainfall
FAO	-	Food and Agricultural Organization
GIS	-	Geographic Information System
IADP	-	Integrated Agricultural Development Project
IRRI	-	International Rice Research Institute
IR	-	Irrigation
ISA	-	Irrigation Schedule Area
JICA	-	Japan International Co-operation Agency
JPS	-	Jabatan Pengairan dan Saliran
KADA	-	Kemubu Agricultural Development Authority
MADA	-	Malaysian Agricultural Development Authority
NIADB	-	National Irrigation Administration and Asian Development Bank
NWMP	-	National Water Management Policy
NWU	-	Net Water Use
OPP2	-	Second Outline Perspective Plan
PBLS	-	Northwest Selangor Agricultural Development Project
RWS	-	Relative Water Supply
SP	-	Seepage and Percolation

CHAPTER 1

INTRODUCTION

General

Irrigation systems are primary methods for maintaining agricultural production through reduction of soil-water deficits. At present there are more than 227 million hectares of irrigated land in the world, most of which have been developed in modern times. Although irrigation is contributing to the world food production, there is reduced interest in irrigation because of the overall low performance of most irrigation systems in the developing countries and the adverse effects on the environment caused by irrigation (Feyen, 1992).

In Asia, rice in irrigated and rainfed lowland environments is mostly grown under flooded conditions, contributing from 90%-95% of world production (Pathak et al., 1991). To achieve this, fields are bunded and soils are puddled by plowing at water saturated conditions, followed by harrowing and leveling. More than 75% of global rice production is harvested from irrigated rice ecosystems, which cover 55% of global harvested rice area. About 25% of the total rice hectarage is under rainfed lowland cultivation, and produces 17% of global rice production (IRRI, 1993). In irrigated rice ecosystems, the availability of water for agriculture is threatened in many places by increasing urban and industrial demand. In view of the projected increase in rice

demands from a growing world population (65% increase from 1992 to 2020; IRRI, 1993), efficient use of water resources in rice ecosystems is of crucial importance.

In drier parts of the world the role of irrigation is of great importance for, without it, agriculture would not be possible in many areas. In Malaysia, irrigation has since been exclusively devoted to the cultivation of wet paddy. The total land area planted to paddy in Malaysia is about 600,545 ha. Of which approximately 340,619 ha. are serviced by irrigation facilities, mainly for the purpose of cultivating rice crops two times a year or commonly known as double cropping. The remaining 259,926 ha. depend upon available rainfall for cultivation (APO, 1991).

The Malaysian Government policies that affect rice production industry are the Second Outline Perspective Plan 1991 - 2000 (OPP2); and the National Agricultural Policy 1992 - 2010 (NAP). The OPP2 has stated, among other pertinent issues, that the agriculture sector will have to compete for various resources with other higher growth sectors like manufacturing and services industries. "Resources" here includes water, a very important ingredient in rice cultivation.

The NAP has targeted rice production in Malaysia to achieve a self-sufficiency level of 65%. It further states that this level of production shall be met from the eight Granary Areas with a combined paddy area of 210,500 ha. And the mini granary areas totaling 28,500 ha. of paddy land. Granary areas refer to major rice growing areas in the country. The eight granary areas are Muda Agricultural Development Authority (MADA) in Kedah, Kemubu Agricultural Development Authority (KADA) in Kelantan. Integrated Agricultural Development Project (IADP) Kerian/Sungai Manik in Perak,

IADP Barat Laut Selangor, IADP Pulau Pinang in Penang, Seberang Perak in Perak, IADP Kemasin-Semerak in Kelantan, and Project pembangunan Pertanian Terengganu Utara (KETARA) in Terengganu. Among them, MADA has the largest area of 97,000 ha. and KETARA has the smallest area of 5,100 ha. (Chong, 1999).

Management of irrigation water has been a challenging issue. More concentration has been geared towards the improvement of system management. There has been an increasing demand for water and at the same time a growing scarcity of water resources. A good irrigation water management that provide adequate and timely irrigation water is important to improve the crop production. To achieve this it is necessary to have an adequate water source, a good conveyance system to carry the water and distribution system to spread the water over the land. Poor water management resulting in either over or under irrigation remains to be a problem of most irrigation systems in developing countries. Another problem is land and water allocation for some periods when the extent of water availability is very uncertain particularly during the dry seasons.

Water management for rice irrigation project needs a large amount of spatial data for its analysis. The Geographic Information Systems (GIS) can be a useful tool. GIS are computerized systems for the storage, retrieval, manipulation, analysis and display of geographically referenced data. In recent year GIS have emerged as new powerful tools for spatial analysis and effective management of water resources. GIS can solve the problems of sorting and up-dating the large amount of newly available data. Besides, GIS can easily locate the control structures and leaking points in the water supply system. As a result large amount of data on crop irrigation and management can

be easily processed by the techniques in GIS. However, none of the Malaysian granaries is currently using GIS in the irrigation water management.

This study will result in having a database in GIS where a large amount of relevant water management data is centrally stored and can be easily accessible to all concerned water manager even at other locations. This work also provides access to physical and management data simultaneously to increase the efficiency in monitoring the water distribution system for improving the irrigation operation and scheduling so that timely preventive maintenance can be carried out by increasing the speed of handling problems related to water management.

Statement of the Problem

Sound water source and a good distribution network is a precondition of an irrigation project. But at this moment the Tanjong Karang Irrigation Project is experiencing several problems like shortage of irrigation water due to the environmental changes, siltation of feeder and main canals, leakages of control gates and other maintenance and operational problems. The main source of irrigation water of the project is Bernam River Runoff and the rainfall. But the runoff of the Bernam river has gradually decreased in recent years. That is happening due to the decrease of annual and seasonal basin rainfall (Syed, 1995).

In irrigation water management, there are problems of up-dating the large amount of newly available data and producing the map which is costly, time consuming and even not convenient to carry around especially in the fields. Besides that, the topographic map in paper form and the statistical data in descriptive form cannot be

simultaneously accessed. Thus it is difficult to establish the relationship between the map and the descriptive data. With the GIS, these data are combined together to give an overall clear picture of the spatial relationship between the map features. The rapid development in computer technology and high demand to process large amounts of data are the main reasons to cause the wide use of GIS application in irrigation water management. GIS gives the ability to collect and manage large volumes of complex spatially-referenced data, which can then be used to research some of the problems which are currently being faced by the project. Besides that, with the capability to combine the spatial information from different sources into a single geographically referenced set of information layers, GIS can significantly increase the speed in which data can be retrieved, interrelated and used. This study will pave the way in the use of GIS to ease the management of irrigation water distribution especially at the tailend of the irrigation scheme during low flows.

Objectives

The main objective of the study was to develop a water management programme for the Tanjung Karang Rice Irrigation Project using GIS. The specific objectives of the study were:

1. To develop an appropriate irrigation water budget for dry and normal year.
2. To develop an overall water management schedule for the scheme.
3. To identify potential water stress areas based on soil series.

CHAPTER II

LITERATURE REVIEW

Irrigation Water Management for Rice

Rice cultivation in Malaysia is concentrated in the Granary Areas. Irrigation facilities, including water resources, water distribution systems, a series of regulating and control structures, and a network of farm roads have been provided to enable double cropping of rice. The two crops are referred to as main-season crop, which is planted during the wet season of the year (August to December); and off-season crop, which is planted in the drier part of the year (Feb to Jun). In rice cultivation practices, water is supplied to the fields in two stages. The first stage is termed pre-saturation supply where water is supplied at a relatively high rate and short duration, followed by the second stage termed as the supplementary supply for the rest of the season. The rate of supplementary supply is usually half that of pre-saturation supply. In terms of duration, pre-saturation supply usually takes about 2 to 4 weeks, and the supplementary supply shall last the entire growth duration of the crop. For the present short-term variety suitable for double cropping, the growth period is between 126 to 145 days (Tan, 1987). Generally, the paddy plants do not consume water supplied during pre-saturation period. This pre-saturation supply is meant for land preparation prior to planting activity (Thavaraj, 1975).